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Multithreading

Custom Locks

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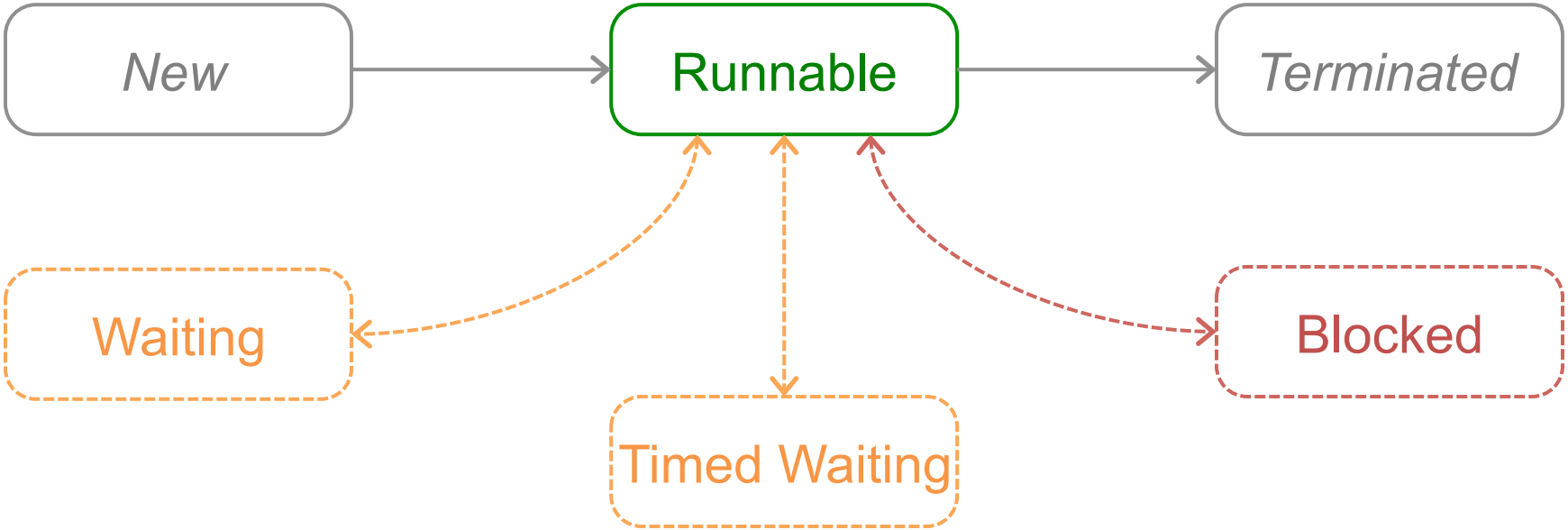
Thread States



http://docs.oracle.com/javase/8/docs/api/java/lang/Thread.State.html

Motivation

- Need **multithreading** to speedup calculation for large, complex problems
- Need **synchronization** to protect data (**memory consistency**) and operations (**atomicity**)
- The **synchronized** keyword causes **blocking**, reducing the speedup needed in the first place

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Motivation

- **Assume have a large shared data structure**
  - When is it okay to read from this data structure?
  - When is it okay to write to this data structure?
- **What operations may occur concurrently?**
  - Thread 1 reads A, Thread 2 reads A
  - Thread 1 reads A, Thread 2 writes A
  - Thread 1 writes A, Thread 2 writes A

Motivation

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  - Thread 1 reads A, Thread 2 reads A
  - ~~Thread 1 reads A, Thread 2 writes A~~
  - ~~Thread 1 writes A, Thread 2 writes A~~

Concurrent Operations

- **Mutual Exclusion**
  - Only one thread may enter synchronized code at a time (blocking other threads)
  - Lots of blocking defeats purpose of multithreading
- **Conditional Synchronization**
  - Only block if certain conditions are true
  - Uses a combination of wait() and notify()

Using Wait and Notify

- A thread will keep its locks during **sleep()**
  - Rarely appropriate, except for debugging
- A thread releases its lock during **wait**()
  - Hence why **wait**() must be called on the lock object in the synchronized block
  - Only return from **wait**() if able to reacquire lock

Using Wait and Notify

- Both **wait**() and **notify**() require lock objects
  - Can have threads waiting on different locks
- Only one waiting thread woken up by **notify**()
- All threads waiting on lock woken up by notifyAll()
  - Usually used, despite sometimes being slower
  - Place **wait**() in while loop to make sure thread woke up for the correct reason

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Custom Lock Class

- May read to shared data structure if…
  - No other threads are writing to it
- May write to shared data structure if…
  - No other threads are reading from it
  - No other threads are writing to it
- Must track…
  - Number of active readers and writers

http://docs.oracle.com/javase/8/docs/api/java/util/concurrent/locks/ReadWriteLock.html

Creating a Custom Lock Class

- Lock Methods
  - Wait until safe to acquire lock
  - Use a loop to avoid spurious wakeups
  - Use wait() and notifyAll() to avoid busy-wait
  - Increase number of threads with lock
- Unlock Methods
  - Decrease number of threads with lock
  - Wake up threads if necessary using notifyAll()

https://docs.oracle.com/javase/8/docs/api/java/util/concurrent/locks/Condition.html

Using a Custom Lock Class

```
1  CustomLock lock = new CustomLock();
2  SharedData data = new SharedData();
3
4  lock.lockReadOnly();     // protects read-only operations
5  data.read();
6  lock.unlockReadOnly();
7
8  lock.lockReadWrite();       // protects write operations
9  data.read();             // or read/write operations
10 data.write();
11 lock.unlockReadWrite();
```


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Creating a Custom Lock Class

```
1  public synchronized void lockReadOnly() {
2      while (writers > 0) {
3          try {
4              this.wait();
5          }
6          catch (InterruptedException e) {
7              // log the exception
8          }
9      }
10     readers++;
11 }
```

Built-in Lock Objects

- See java.util.concurrent.locks
  - May not actually use any of these in class, but might be useful for debugging and testing
- Closest to ReentrantReadWriteLock
  - Our version prone to starvation
  - Their version provides a fairness policy

http://docs.oracle.com/javase/8/docs/api/java/util/concurrent/locks/package-summary.html

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